E-ISSN: 2710-2122, P-ISSN: 2710-2114
2022: Vol 4, pp 28-43. https://doi.org/10.51986/ijer-2022.vol4.03
Interdisciplinary Journal of Education Research

The Impact of Take-home Open-book Examinations due to COVID-19 among Business Students. Do Gender, Age, and Academic Skills Matter?

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DOI: 10.51986/ijer-2022.vol4.03

Abstract: *Due to COVID-19, numerous universities and colleges have been forced to arrange home-based exams in many countries. We know relatively little about what consequences this might have for the ranking of students based on qualifications in the various subjects. This is an important issue for administrators, educators, and others involved in planning the design of higher education. The intention of this article is to get more insight into this issue. By analysing administrative data from a Norwegian Business School, we examined the impact of moving from traditional school exams to home-based exams in 2020 due to COVID-19. The chosen methodology is the comparison of means by using t-test and standard linear regression models. The results indicate a weaker link between high school performance and achievements in business administration courses. Furthermore, home-based exams might disadvantage older students. This is useful knowledge in the judgement as to whether or not to introduce home-based exams as a permanent arrangement.*

Keywords: COVID-19, Online exam, Home-based exam, Traditional in-class exam, Business students, Grades, Performance, Gender, Age.

1. Introduction

There are different practices throughout higher education. In some subjects, there is a Take-Home (open-book) Examination (THE), and in others, there is a traditional in-class exam (ICE). THEs have been used among business students in Norway, mainly at the master's level. Due to corona and the lockdown, it has been necessary to apply THEs for all courses. The shutdown came unexpectedly and created challenges both in terms of teaching and organising exams (Alasoluyi,2021: Jimola & Ofodu, 2021; Olawale et al., 2021, Omodan, 2021). Online home exams had to be implemented in all subjects with limited time for good planning. This led to different strategies. In the most quantitative subjects (mathematics, business statistics, and economics), the grades were replaced with a pass or fail. In some subjects (for instance, accounting), questions were altered by designing more difficult questions, while in other subjects, no substantial changes were made (management, marketing). It was up to the lecturers of the different courses to make this choice. Also, some colleges in Norway are considering continuing with home exams as a norm after the pandemic has receded. Routines have been introduced for this kind of exam, and there are many administrative benefits. They are easier to manage and require fewer resources (no travel is necessary, acquiring and renting suitable premises is not required, there are no local restrictions and no logistical challenges). Elsewhere in the world, similar considerations are being made (Chadha et al., 2020).

A key question is whether THEs measure the same level of knowledge as ICEs among business students at bachelor's level. There is a large body of literature about choosing between take-home and traditional tests in class with closed-book exams (Bengtsson, 2019). There is challenging if the exam consists of calculations with only one correct answer or simple questions with low complexity (Roelle & Berthold, 2017). The research suggests that for these types of questions, students perform significantly better using ICEs. The bachelor's degree in business subjects is characterised by modules which have these types of assignments.

Cite this article (APA):
Opstad, L., & Pettersen, I. (2022). The impact of take-home open-book examinations due to COVID-19 among business students. Do gender, age, and academic skills matter? *Interdisciplinary Journal of Education Research, 4*, 28-43. https://doi.org/10.51986/ijer-2022.vol4.03

This article aims to evaluate ICEs during COVID-19 for business courses at the bachelor level. Sarfraz et al. (2022) investigate how expectancy (performance and effort) and facilitating conditions influence students' performance during COVID-19. This paper has another approach. By using background information about the individual student (gender, admission points, math background, etc.) and the application of a regression model, this research explores if the degree of explanatory power is the same in 2020 (COVID-19 and THEs) compared with previous years (2017–2019). The students are ranked depending on their grade scores. Therefore, the grading system is a key factor (Opstad, 2021a). Two students who perform identically and have a qualification in the same subject should receive identical grades. If this is not the case, the ranking of the students does not give the correct information for admission to further studies or to future employers. Due to this, it is very important to ensure that the exam results give a correct picture of the students' qualifications, independent of the format of the exam. This depends on the ability to create valid and reliable measurements (Senel & Senel, 2021b). This is a critical factor for achieving educational goals (Chen et al., 2020).

2. Literature and a model explaining success in business courses.

The exam result should be an indicator of knowledge and skills in the various subjects. Both the kind of questions and the form of the exam can measure different dimensions and affect the students' efforts and the way they obtain knowledge. The argument for ICEs is that they lead to a deeper form of learning and measure a higher level of the taxonomy scale (Johanns et al., 2017). One of the reasons for this is the students have more time available in THEs. Another factor is student wellbeing. Examinations in a home environment where one can relax, read notes and textbooks, search the Internet, and consult others feel less tense (Akulwar-Tajane et al., 2021; Dave et al., 2020; Özdin & Bayrak Özdin, 2020). Therefore, weak and nervous students have more success (Spiegel & Nivette, 2021). A more positive attitude towards the exam form (a THE) can improve the students' performance (Senel & Senel, 2021a). However, the findings are mixed. If the available time and exam design are identical, the students might not be less anxious with home-based exams (Durning et al., 2016).

2.1 Factors explaining the grades in business studies

Numerous studies have identified students who have succeeded in business studies. Figure 1 is constructed based on findings in previously published articles.

Box A in Figure 1 provides an overview of some key factors. Gender matters. Johnson et al. (2014) report that males tend to outperform females. Other studies do not find any gender difference (Parker, 2006). Several researchers report a positive relationship between mathematical performance and success in business schools (Arnold & Straten, 2012; Opstad, 2018). Several published articles suggest a positive link between grade point average from upper secondary school (HSGPA stands for high school grade point average) and success in economics and business courses (Opstad & Fallan, 2010). High GPA scores from upper secondary schools can be a good predictor of success in many business and economic courses (Brookshire & Palocsay, 2005). Students' efforts and attendance also influence performance (Bonesrønning & Opstad, 2012; Horn & Jansen, 2009; Stinebrickner & Stinebrickner, 2008). Personality traits also correlate with performance in business administrative courses (Lakhal et al., 2015; Opstad, 2021a). Some researchers report students' age has an impact on their academic performance (Sheard, 2009). The available literature shows a mixed picture of the importance of the various factors on the students' grades. For instance, Vella et al. (2016) found that gender and age have no impact on web-based courses in the USA. Only HSGPA was positively related to the success.

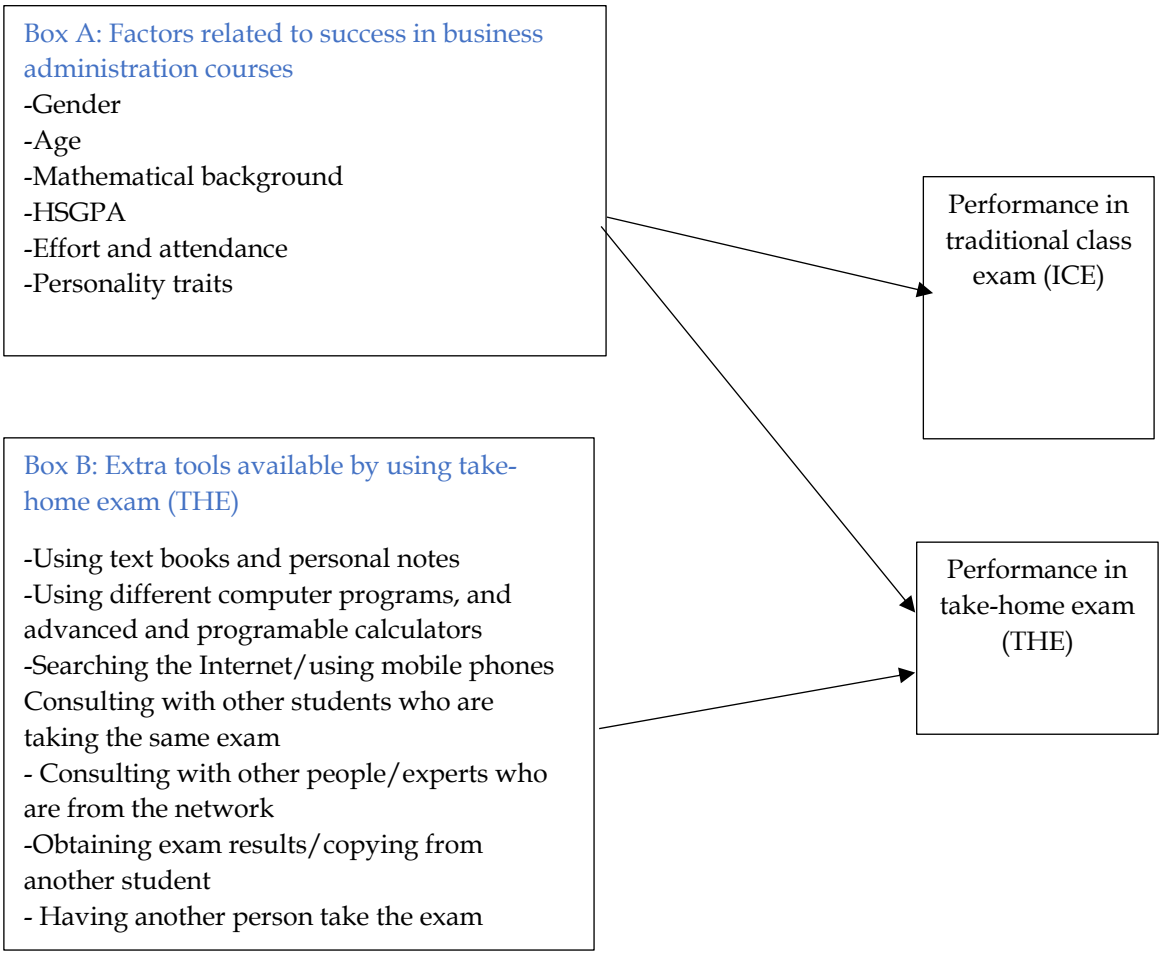

***Figure 1**: The model explaining success in business courses*

THE offers far more flexibility and opportunities to use various aids (permitted or not permitted depending on the instructions). Box B in Figure 1 presents some of the possibilities. It gives a list of extra tools that are not available in the traditional form of the exam.

One option is reading from textbooks (open books) and personal notes. Another possibility is to use the Internet/mobile phone or other advanced aids. Some courses give permission to students to use these methods, while in other cases, this is unacceptable behaviour. Most home-based exams require independent individual work. Therefore, communicating with others or copying answers from the Internet is considered cheating. Another opportunity might be to apply different kinds of computer programs. Some of them can be quite advanced.

2.2 Hypotheses

Based on the goal of this study, previous research and Figure 1, we postulate two hypotheses.

- H1 (Hypothesis 1): There is a link between students' background and qualifications and exam grades in business courses using a traditional class-based exam.

To answer this hypothesis, we take the points stated in Box A in Figure 1, but with the exception of effort, attendance and personality traits. We expect better math qualifications and higher GPA from upper secondary school to be positively related to the grade in business subjects (Arnold & Rawaan, 2014; Cannonier & Smith, 2019). When it comes to gender and age, the research shows divergent results. Therefore, we make no suggestions about whether there is a positive or negative correlation with performance.

- H2 (Hypothesis 2): Correlations between students' background and qualifications and exam grades in business courses are different depending on whether a traditional school exam or home exam is implemented.

The factors in Box B are unobserved variables. The research shows they have an impact on performance (Adigun et al., 2021; Bilen & Matros, 2021). This analysis assumes that these elements will affect the final grade. These components are assumed to influence the grades of the students. Consequently, the relationship between students' background and qualifications and exam grades in business courses can be different. This is the background for the presentation of hypothesis 2.

3. Methodology and Data

3.1 The sample and descriptive statistics

The data used in the study are available for undergraduates from NTNU Business School over four years (2017–2020). This is administrative data. It contains the exam results for all students in all subjects during this period (more than 20,000 observations). This includes individual data on admission quality (grades from upper secondary school), gender, age, geographical location, and mathematical background. In upper secondary school, the students can choose between practical mathematics (P-maths), mathematics for business and social science (S-maths), or mathematics for natural science (N-maths). The N-path is particularly relevant for students entering university to study technical and natural sciences. The S-path is suitable for students applying to university to study economics, finance, and business administration. Both S- and N-maths emphasise a theoretical presentation of mathematics. Before the shutdown of society, there were traditional school exams in almost all the subjects at bachelor level. An example of an exception is the mandatory bachelor's thesis in the third year. Due to COVID-19, only home-based exams were administered in 2020.

The composition of the student body at bachelor's level was quite similar during the period 2017-2020 (See Table 1). It was quite a low average age (between 21 and 22 years), but there were also students who were older than 40 (Figure 2). Less than 10 per cent of students have backgrounds in N-maths. However, S-maths are quite popular, and about one out of three students selected S-maths in upper secondary school. Due to high demand, good qualifications are needed to get access to the undergraduate programmes. This explains the high score from upper secondary school. The majority of the students come from other regions.

Table 1*: Descriptive data, Mean value, Compulsory courses 2017–2020 (first year) for the Bachelor's degree in Business Administration*

	2017–2018	2019	2020
Gender (0:F,1:M)	.54	.61	.56
Age	21.50	21.32	21.87
S-maths (0:Non S-math, 1:S-math)	.34	.36	.31
N-maths (O:Non N-math, 1 : N-math)	.087	.10	.095
HSGPA(GPA upper secondary school) (Grading 0, 1, 2, 3, 4, 5, 6 where 6 is the top score)	4.70	4.74	4.78
Norwegian language (upper secondary school) (Grading 0, 1, 2, 3, 4, 5, 6 where 6 is the top score)	4.32	4.37	4.46
Local (0: Non Local student, 1: Local student 9	0.456	.460	.460
N	650	350	421

The performance and the numbers of students vary slightly from one year to another (Table 2). First-year students (see Introduction to Marketing and Financial Accounts with Analysis) had a weaker average grade in 2018 and 2019 compared to the two following years. By comparing 2017–2019 with traditional school exams with the year 2020 (when home exams were used), the tendency is a marginal better mean grade and lower standard deviations, namely a smaller spread of the grades (cf. Table 3).

***Table 2**: Descriptive statistics. Performance*

	2017(ICE)	2018 (ICE)	2019 (TCE)	2020 (THE)
Introduction to Marketing	3.24 (0.96) N=331	2.78 (1.17) N=328	2.85 (1.05) N=363	3.11 (1.01) N=444
Financial Accounts with Analysis	3.04 (1.48) N=272	2.66 (1.50) N=287	2.78 (1.72) N=315	3.63 (1.36) N=406
Business Strategy	3.05 (1.10) N=278	3.05 (0.94) N=276	2.98 (1.19) N=301	3.14 (0.80) N=106
Applied Microeconomics	3.40 (1,34) N=149	3.33 (1.40) N=172	3.10 (1.38) N=147	3.67 (1.43) N=61
All subjects	3.13 (1.30) N=5 877	3.14 (1.38) N= 6 065	3.15 (1.34) N=6 102	3.21 (1.20) N=5 450

Notes: SEs in parentheses. 0: F, 1: E, 2: D, 3: C, 4: B, 5: A

***Table 3**: Distribution of the Grades, All courses*

	2017–2019 (%)	2020(%)
F	6.0	5.5
E	7.0	7.3
D	13.8	13.8
C	28.9	27.9
B	30.0	31.0
A	14.3	14.4
Total	100	100

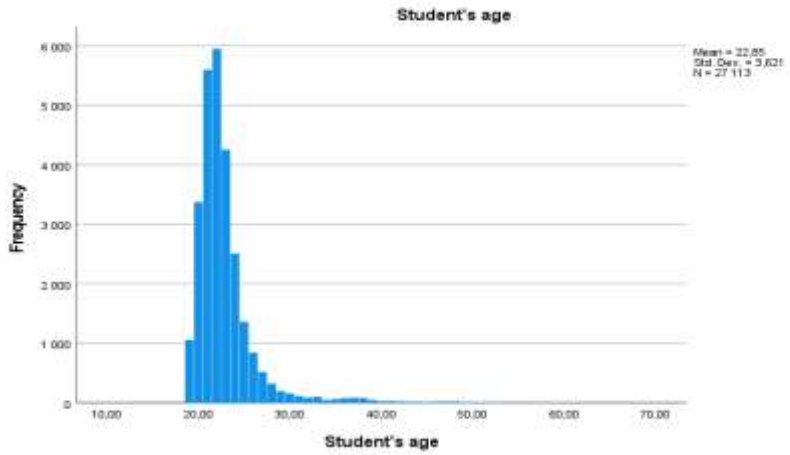

***Figure 2**: Distribution of Age*

3.2 Method of data analysis

This survey is based solely on available information from NTNU databases (cf. Section 3.1). It consists of quite detailed information. Unfortunately, we lack data on personal characteristics and students' efforts and attendance, therefore, we have concentrated on the other factors (gender, age, quality of admission, maths background, etc.). This study uses a quantitative approach. One can choose between different approaches, and we limit ourselves to two methods, namely an

independent sample t-test by comparing means and a linear regression model. In the independent t-test, students' performance is compared before and after COVID-19 to see if it has any significant effects. The students are divided into different age groups distributed by gender: under 25 years, between 25 and 30 years, and over 30 years. The t-test is used to answer hypothesis 2.

The other approach uses standard linear regression models. An advantage of this method is that it gives the effects by including different explanatory variables simultaneously. Based on the research objectives and hypotheses, the following model is selected:

$$Y_i = a_0 + a_1 \mathrm{X1}_i + a_2 \mathrm{X2}_i + a_3 \mathrm{X3}_i + a_4 \mathrm{X4}_i + a_5 \mathrm{X5}_i + a_6 \mathrm{X6}_i + a_7 \mathrm{X7}_i + \varepsilon_i$$

where:

Y = the grade attained in business subjects (0: F, 1: E, 2: D, 3: C, 4: B, 5: A),

i = student,

α_0 = constant,

X_1 = gender (0: F, 1: M),

X_5 = upper secondary school HSGPA, mean score for all subjects (1: Fail, 6: Top grade)

X_4 = dummy variable for N-maths (0: did not take N-maths, 1: took N-maths),

X_2 = Student's age (1:18–19, 2:20, 3:21, 4:22 , 5:23, 6:24, 7:25–26, 8:27–30, 9:31–38, 10:39–60),

X_3 = dummy variable for S-maths (0: did not take S-maths, 1: took S-maths),

X_6 = score in the Norwegian language from upper secondary school (Score from 1 to 6, where 6 is the top value).

X_7 = dummy variable for the student's geographical affiliation (1: locally connected to the region around Trondheim, 0: otherwise),

ε = stochastic error.

The finding in the regression models will answer both hypotheses. The age distribution is very skewed. To reduce the value of skewness and kurtosis, the age of the students is divided into intervals. Due to multicollinearity, P-maths is not included as an independent variable. By presenting the results before and after 2020, we can analyse how the shutdown affects the estimated parameters. We have merged 2017 and 2018. The year 2019 will be presented separately in order to directly compare the figures with the results during COVID-19 in 2020.

Some courses are selected for more in-depth investigation in the analysis: two from the first year (Introduction to Marketing and Financial Accounts with Analysis) and two from the second year (Business Strategy and Applied Microeconomics). For most quantitative subjects, the grading scale was pass or fail during COVID-19 (2020). An exception was Applied Microeconomics. Therefore, this subject was included in this study. Questions requiring long written answers might favour students who are more able in their written presentation. This may explain a link to the performance in the Norwegian language at upper secondary school. A high proportion of the students come from other regions. They can choose from several alternative business schools. They prefer to study in Trondheim, and they can be distinguished from the students belonging to the same region as the NTNU Business school.

4. Presentation of data and findings

The paired comparisons may indicate that THEs favour male students (Table 4a). This is especially true for students under the age of 25 (Table 4b). Obviously, age matters. For the group between 25 and 30 years (Table 4c), there is no significant difference between the two exam forms. Those over the age of 30 have a significantly lower average grade (Table 4d), while the opposite is true for those under the age of 25. For female students, the differences are not significant. The t-test confirms hypothesis 2 regarding age and gender.

4.1 T-test of gender and age (Hypothesis 2)

***Table 4a**: Pairwise comparisons of mean success before and during COVID-19 divided into gender. T-test (assuming equal variances).*

	Before 2020 (ICE)	2020 (THE)	Diff	Sig (2-tails)
Males	3.15	3.21	-.0597	0.027 **
N	11 359	3121	(.0270)	
Females	3.19	3.22	-.0308	.288
N	10304	2329	(.0290)	
All	3.17	3.21	-.0456	0.021**
N	21 663	5 440	(.0197)	

Notes: SEs in parentheses.***p < 0.01, **p < 0.05 and *p < 0.1

***Table 4b**: Pairwise comparisons of mean success before and during COVID-19 for students younger than 25 years divided into gender. T-test (assuming equal variances).*

	Before 2020 (TCE)	2020 (THE)	Diff	Sig (2-tailed)
Males	3.23	3.31	-0.0823	0.004***
N	9 592	2 618	(0.0288)	
Females	3.29	3.33	-.0388	0.201
N	8 583	1 958	(0.0303)	
All	3.26	3.32	0.0609	0.004***
N	18 175	4 576	(0.0209)	

Notes: SEs in parentheses.***p < 0.01, **p < 0.05 and *p < 0.1

***Table 4c**: Pairwise comparisons of mean success before and during COVID-19 for students between 25 and 30 years divided into gender. T-test (assuming equal variances).*

	Before 2020 (ICE)	2020 (THE)	Diff	Sig (2-tailed)
Males	2.79	2.90	-0.0981	0.228
N	1 419	385	(0.0814)	
Females	2.77	2.78	-0.137	0.882
N	1 177	265	(0.0926)	
All	2.78	2.85	-0.0650	0.288
N	2 596	650	(0.0611)	

Notes: SEs in parentheses.***p < 0.01, **p < 0.05 and *p < 0.1

***Table 4d:** Pairwise comparisons of mean success before and during COVID-19 for students older than 30 years divided into gender. T-test (assuming equal variances).*

	Before 2020 (TCE)	2020 (THE)	Diff	Sig
Males	2.54	2.19	0.35	0.054*
N	382	74	(0.1815)	
Females	2.52	2.29	0.2220	0.189
N	492	83	(0.1689)	
All	2.52	2.24	0.2805	0.023**
N	875	157	(0.1234)	

Notes: SEs in parentheses.***p < 0.01, **p < 0.05 and *p < 0.1

4.2 The regression models (Hypothesis 1 and 2)

The findings are presented in tables 5 to 9. Results for 20017-2019 are linked to hypothesis 1, while the differences between findings in 2020 and previous years provide an answer to hypothesis 2.

The regression model for all courses (Table 5) reports a significant positive correlation between performance and the variables S-math, N-math and HSGPA for the years 2017–2019 with a traditional classroom exam. S-math has a significant positive link to performance. However, the strongest correlations are between HSGA and achievements, with the coefficient (B) around 0.2. The gender effect is rather low (B is less than 0.05). It is significantly in favour of males in 2017–2018 and in favour of females in 2019. Students from other regions tend to outperform the local students (this is strongly significant). Norwegian language grades from upper secondary school are not significantly related to the achieved grades. Home-based exams under COVID-19 report different results. First, the relationship between performance and HSGPA is smaller (coefficient B has been reduced from around 0.2 to 0.15) but still strongly significant. The link to the S-mathematical background is also smaller. There is no further significant connection for students with N-maths. Furthermore, the significant positive relationship between age and grade scores has vanished.

Table 5: *Result from the regression model including all courses (Performance as dependent variable) Accepted values of Variance inflation factor (VIF))*

	2017–2018 (ICE)		2019 (ICE)		2020 (THE)	
	Standardised B	Sig	Standardised B	Sig	Standardised B	Sig
Gender	0.032	0.001***	-0.039	0.004***	0.023	0.134
Age	0.010	0.352	0.026	0.072*	-0.013	0.421
S-math	0.085	0.000***	0.078	0.000***	0.052	0.001***
N-maths	0.018	0.061*	0.026	0.050	0.004	0.789
HSGPA (Upper Secondary)	0.203	0.000***	0.222	0.000***	0.158	0.000***
Norwegian (Upper Secondary)	-0.010	0.385	0.010	0.538	0.016	0.414
Local	-0.101	0.000***	-0.077	0.000***	-0.068	0.000***
	N = 10662, Adj. R^{sq}= 0.058,		N=5495, Adj. R^{sq}=0.069		N= 5076, Adj. R^{sq}= 0.038	

Notes: p < 0.01, **p < 0.05 and *p < 0.1, sig = significant level

Results from the individual courses presented indicate that the independent variables have different effects depending on which subjects are analysed (Tables 6–9). For the non-quantitative subjects (Marketing and Business Strategy, Tables 6 and 8) it is primarily HSGPA that is significantly correlated with performance. In home-based exams during COVID 19, this effect is gone. There is no link between HSGPA and results. The same pattern is observed for the subject Financial Accounts with Analysis and the quantitative course Applied Microeconomics (Tables 7 and 9).

The link between age and performance varies among the courses using a traditional school exam. For the non-quantitative course Business Strategy there is no significant trend related to age and choice of exam form. For Introduction to Marketing, the connection is significantly negative in 2017–2018, but not in 2019. In 2020 the correlation is more strongly negative than in 2017–2018. For the two quantitative courses (Tables 7 and 9), there is a weak connection (or none) between age and achievement using traditional exam forms. By introducing a home based-exam in 2020, this association is strongly negatively related to Applied Microeconomics. Notice also that when using ICE, the tendency is a significantly positive relationship between S-math and performance (with the exception of Applied Microeconomics). Changing to THE, this correlation disappears for the courses presented.

Table 6: *Result from regression model with performance in the compulsory course Introduction to Marketing as a dependent variable (first year). (Accepted values of Variance inflation factor [VIF])*

	2017–2018 (ICE) Standardised B	Sig.	2019 (ICE) Standardised B	Sig	2020 (THE) Standardised B	Sig
Gender	0.067	0.093*	-0.078	0.150	0.018	0.715
Age	-0.086	0.050*	0.113	0.057*	-0.138	0.011**
S-math	0.058	0.161	0.096	0.086*	0.069	0.186
N-maths	-0.024	0.552	-0.016	0.764	0.072	0.150
HSGPA	0.223	0.000***	0.161	0.019**	0.042	0.551
Norwegian (Upper Secondary)	0.037	0.444	0.109	0.110	-0.024	0.726
Local	-0.130 N=611, Adj. R^{sq}=0.105	0.001	-0.027 N= 349, Adj. R^{sq}=0.050	0.509	-0.020 N=420, Adj. R^{sq}= 0.018	0.685

Notes: p < 0.01, **p < 0.05 and *p < 0.1, sig = significant level

Table 7: *Result from regression model with performance in the compulsory course Financial Accounts with Analysis as dependent variable (first year). (Accepted values of Variance inflation factor [VIF])*

	2017–2018 (ICE) Standardised B	Sig.	2019 (ICE) Standardised B	Sig	2020 (THE) Standardised B	Sig
Gender	0.002	0.961	-0.091	0.119	0.132	0.009***
Age	-0.033	0.483	0.02	0.970	-0.149	0.001***
S-math	0.121	0.008***	0.143	0.021**	0.224	0.132
N-maths	0.040	0.362	0.098	0.101	-0.221	0.346
HSGPA	0.230	0.000***	0.193	0.009***	0.299	0.248
Norwegian (Upper - Secondary)	-0.158	0.004***	-0.070	0.314	0.145	0.316
Local	-0.115 N=529, Adj. R^{sq}=0.057	0.008***	-0.109 N=295, Adj. R^{sq}=0.084	0.059*	-0.028 N=388, Adj. R^{sq}=0.073	0.833

Notes: p < 0.01, **p < 0.05 and *p < 0.1, sig = significant level

Table 8*: Result from regression model with performance in the compulsory course Business Strategy as dependent variable (second year). (Accepted values of Variance inflation factor [VIF])*

	2017–2018 (ICE) Standardised B	Sig	2019 (THE) Standardised B	Sig	2020 (THE) Standardised B	Sig
Gender	-0.065	0.148	-0.142	0.017**	-0.147	0.171
Age	-0.072	0.128	-0.101	0.136	0.064	0.546
S-math	0.094	0.041**	0.070	0.252	0.001	0.990
N-maths	0.006	0.888	0.069	0.244	0.137	0.197
HSGPA	0.114	0.040**	0.179	0.016**	0.023	0.872
Norwegian (Upper Secondary)	-0.013	0.817	0.021	0.762	0.110	0.456
Local	-0.070 N=521, Adj. R^{sq}=0.039	0.112	-0.009 N=282, Adj. R^{sq}=0.094	0.878	0.054 N=97, Adj. R^{sq}=0.010	0.606

Notes: p < 0.01, **p < 0.05 and *p < 0.1, sig = significant level

***Table 9**: Result from regression model with performance in non-compulsory course Applied Microeconomics as dependent variable (second year). (Accepted values of Variance inflation factor [VIF])*

	2017–2018 (ICE)		2019 (ICE)		2020 (THE)	
	Standardised B	Sig	Standardised B	Sig	Standardised B	Sig
Gender	-0.046	0.428	-0.093	0.274	-0.07	0.433
Age	-0.112	0.072*	-0.080	0.359	-0.458	0.010**
S-math	0.093	0.122	-0.034	0.696	-0.104	0.476
N-maths	-0.031	0.588	-0.052	0.532	-0.018	0.900
HSGPA	0.192	0.006***	0.306	0.003***	0.065	0.700
Norwegian (Upper Secondary)	-0.074	0.264	0.030	0.766	-0.143	0.341
Local	-0.081	0.159	-0.213	0.010**	0.115	0.341
	N=311, Adj. R^{sq}=0.067		N=140, Adj. R^{sq}=0.170		N=57, Adj. R^{sq}=0.105	

Notes: p < 0.01, **p < 0.05 and *p < 0.1, sig = significant level

The results from the regression models confirm both hypotheses. Students' backgrounds and qualifications are related to performance in business administration courses. The strength of these connections depends on the choice between traditional school exams or home-based online exams. Both the pairwise comparisons of means and the regression models indicate different explanatory variables depending on the selected exam form (THE or ICE). Applying ICE, our analyses show there is no longer any significant correlation between performance and the two independent variables, S-maths and HSGPA, while students' age showed a stronger, significantly negative impact on success.

5. Discussion

5.1 The link between students' background and qualifications and exam grades in business courses using a traditional class-based exam (ICE) (Hypothesis 1).

This study confirms prior research that the HSGPA score from upper secondary schools is related to performance at a business school. This effect is quite strong among business students. The student's academic score at upper secondary school is a good predictor of the performance in business fields and other university courses (Cohn et al., 2004; Cyrenne & Chan, 2012; Sulphey et al., 2018).

Furthermore, this study verifies that a background in mathematics (S-maths) is positively linked to achievements in business courses. This is in line with prior research (Asian-Chaves et al., 2020, 2021). S-mathematics is specially adapted to business studies. The impact of a mathematics background depends on the type of subject studied in business administration, and it has less effect on non-quantitative subjects. Therefore, there is a significant correlation between accounting subjects (Table 7) but not in Business Strategy (Table 8). This effect also applies to marketing. Somewhat surprisingly, this study finds no connection between mathematics background and performance in Applied Microeconomics (Table 9). Across all subjects, there is a strong link related between mathematical background and success (Table 5).

As a result of more gender equality and more women choosing courses in economics, many have pointed out that the traditional gender gap has narrowed considerably or disappeared. Walstad and Bosshardt (2019) suggest a gender gap in favour of women. Opstad (2021b) reports no gender difference in business mathematics. In line with this development, it is no surprise that this study finds no gender differences or any unambiguous ones. In this work, the trend is that the gender difference might be in favour of women. For instance, there is a significant positive correlation between females and performance in Business Strategy and for all courses in the year 2019.

International research suggests that there is a relationship between English proficiency and performance among undergraduates in economics courses (Geide-Stevenson, 2018). In this study,

there is no correlation between grades in the Norwegian language and success in business courses; and this even applies to the non-quantitative courses. Success in the Norwegian language at upper secondary school is not correlated with success in business courses, according to the findings in this study. There are a lot of articles investigating the connection between ages and success in business studies (Swanepoel et al., 2021). Some factors may favour older students, while others may favour younger ones.

The result in this analysis does not give any unambiguous age effect related to performance using ICE. Students who come from other regions must sacrifice more to attend the NTNU Business school compared to those living in the surrounding area. These students must move to a new environment. Hence, there might be another selection of long-distance attending students. This might explain why this has significance when all courses are included. One observes the same pattern by analysing specific courses, but not all values are significant.

5.2 Are correlations between students' background and qualifications and exam grades in business courses different depending on whether there is a traditional school exam (ICE) or a home exam (THE) implemented? (Hypothesis 2).

5.2.1 The age impact

The findings show that age can have an impact on who succeeds in the two forms of examination. Both the regression models and the pairwise comparisons of means indicate that older students tend to get weaker grades in home-based exams. The effect may vary from subject to subject and seem to apply especially to the quantitative courses (Tables 7 and 9).

The results suggest that home-based exams might disadvantage older students. As the factors included in Box B in the figure are unobserved variables, we lack the information in this research to identify how the various factors affect the performance. The lecturers at NTNU Business school report some changes in the evaluation by having home-based exams due to COVID-19. The assignments become more demanding, and it takes more to achieve a specific grade, such as a C. This means that an identical answer will obtain a weaker grade in a THE compared to a traditional ICE. This could be an explanation for why older students tend to get weaker results with home-based exams. First, it is consistent with the conclusions of Clark et al. (2020) that older students are more honest and less tempted to cheat. The threshold for being dishonest is probably higher for older students. Second, older students are less familiar with using advanced methods that are available with a calculator or the Internet that can help with online exams. Third, there are fewer older students. Therefore, they probably do not have the same level or networks as the younger students. Moreover, some of the older students might only take a few subjects, and thus they are not part of the class to the same extent as the others. Therefore, they will probably have less contact with fellow students, and may have fewer people to contact who can assist them during the exam. These factors may explain why the difference is greatest between the two quantitative subjects. It is precisely in the quantitative subjects that there is most to gain by applying the tools mentioned in Box B. Hence, home exams seem to favour younger students because they can make use of various tools in Box B. Due to a lack of control and oversight, one can also be dishonest, for example, by cooperating with fellow students. As older students do not have the same network and possibilities, they cannot exploit this potential to the same degree as fellow students.

5.2.2 The gender effect

Based on international studies, there is no unambiguous correlation between gender and cheating among business students (Klein et al., 2006). To the extent there is a gender deviation, it suggests that males are more dishonest. The interpretation of the results in this analysis in the pairwise comparisons of means is in line with this conclusion (Table 4). However, the simultaneous regression models do not indicate or confirm this finding. If the males cheated to a significantly greater extent than the females, this would probably have an influence on the values of the coefficients and the significant levels. Therefore, there are probably rather small gender differences among business students in this survey.

5.2.3 Academic success, mathematical background, and other factors

One of the most important findings of this analysis, alongside the age effect, is that performance in home-based exams is much more related to academic success (the GPA from upper secondary school) than in traditional school exams. Unlike in class-based exams, our investigation suggests that there is no link between academic performance in upper secondary school and success in business courses using home-based exams during COVID-19. The same pattern is also seen for mathematical background, but with some mixed results depending on the actual course. The impact is especially strong for the Financial Accounts with Analysis course. Previous studies show that mathematical background has a stronger impact on quantitative subjects (Opstad, 2018). Despite this correlation, this relationship seems to disappear by the exam designs arranged during COVID-19. One interpretation is that ICE favours weak students. Students with high scores from upper secondary school and who have chosen theoretical mathematics have less success in business studies with this kind of exam. This is in line with the suggestion of others (Eurboonyanun et al., 2021). Regarding local affiliation or Norwegian language skills at upper secondary school, it is unclear what relation these might have, depending on the choice between a THE and a ICE.

6. Contribution and limitations

There are few other published studies using regression models to compare business students' performance before and during COVID-19. As this is a topical area, it is important to acquire more knowledge.

The difference in findings depending on exam forms can be due to many factors. This may be the result of the fact that in the case of THEs it is permitted to use the **t**extbooks and personal notes and that the exam is conducted in other settings. Students can take advantage of the fact that, to a greater extent, there is less control in home-based exams. Josien and Broderick (2013) emphasise that students are more likely to cheat in out of classroom exams. Therefore, professors should be careful using home exercises as part of the students' grading. This is especially true in subjects where there are certain correct answers. This analysis suggests that this problem might also apply to the non-quantitative subjects. It is also worrying that the extent of the cheating may have increased over time (Hussein et al., 2018).

Due to COVID-19 and the shutdown of society, the exam form had to be changed at short notice. This analysis suggests that the transition from school-based to home-based exams creates challenges in ensuring the right ranking of the student. Although there are opportunities to improve exam assignments as well as to strengthen the control function, one should be cautious about introducing THE as a standard for undergraduate business students. They can present a challenge if honest students are punished and receive poorer grades than those taking home exams. If a student knows that many others are cheating and are being rewarded for this, the student could be tempted to do the same. Without good control options, the result will be that THE favour dishonest students with good networks. The result can be a completely different ranking than in the use of ICE, especially in quantitative subjects. This may not be the desired development.

This study has some limitations. Data has been collected from only one business school. Therefore, one should be cautious about generalising the results. Data is not available that records how home exams affect the behaviour of students. Hence, key variables are lacking that could explain the possible causes of different results when comparing ICE with THE. As the majority of students are around 23 to 24 years old, it is challenging to use age for explanatory variables in the regression models. An alternative approach is to use dummy variables (see Appendix). This provides the same pattern for the age effect (older than 26 years) for the quantitative subjects as presented in Tables 7 and 9. In addition, the dummy variable gives a strong significant age effect where the older students are disadvantaged in the case of THE in the analyses, including all subjects (Table 5). This confirms the assumption that older students are likely to get worse grades in home-based exams.

7. Conclusion and further research

In this study, younger students perform better than older students. This difference might be because older students are more honest, use less advanced methods, and have a weaker network than younger students. To the extent that there is a gender difference, the scheme favours males. Furthermore, academic performance and mathematical background from upper secondary school are less correlated with the exam results at ICE compared to THE. Hence, theoretically, weaker students will probably benefit from switching to home-based exams. There are many unobserved factors that students apply in varying degrees which will have an influence on degree grades in the case of online exams. This may explain why the link between individual data and qualifications becomes weaker when using home-based exams compared with traditional exam forms. One needs more research about this issue.

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Appendix

Values by using dummy variable for those older than 26 years.[1)] Otherwise, the same model specifications as presented in Tables 5–9.

	2017–2018 (ICE)		2019 (TCE)		2020 (THE)	
	Standardised B	Sig.	Standardised B	Sig.	Standardised B	Sig.
All subjects	-0.24	0.013	-0.023	0.090	-0.073	0.000
Introduction to Marketing	-0.032	0.417	0.015	0.794	-.048	0.342
Financial Accounts with Analysis	-0.166	0.001	0.021	0.716	-0.171	0.001
Business Strategy	-0.77	0.085	-0.075	0.211	0.016	0.883
Applied Microeconomics	-0.072	0.211	-0.092	0.245	-0.231	0.094

1) Dummy variable 0: Below 27, 1: 27 years or older. Notes: for the other variables minor changes are not presented here